TRUCK HAULAGE AT PLANT OF VOLUNTEER PORTLAND CEMENT COMPANY, KNOXVILLE, TENNESSEE

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At Knoxville both the limestone and shale quarries are located roughly one half mile from the plant proper. Both are hillside quarries with good natural drainage, easily accessible from the plant by an open cut through a low, intervening ridge.

The crushers are located at the plant proper. A study of first cost, operating cost and general quarry conditions all favored this. No suitable location for crushers in the quarries was available; the initial quarry faces were low and moved back rapidly so that haulage from the shovel to the crushers would be needed from the start.

In any haulage system the critical part of the operating cycle is the time consumed in loading and dumping, including starting and stopping. With the load in motion at normal travel speed, the distance traveled to the unloading point can be increased considerably at little added cost. At 20 miles per hour, loaded, the travel is 1760 feet per minute, at 30 miles per hour, returning empty, one half mile is covered in one minute. No cheaper transportation from the quarry to the plant could be found.

Another factor was that crushing at the plant could be grouped with one crew handling both limestone and shale crushers.

The original haulage equipment provided for our quarry in 1928 consisted of ten Easton 10-ton side dump cars and one 25-ton Whitcomb gasoline locomotive, running on standard gauge track, for handling both limestone and shale. A single track extended from the crushing plant down to the limestone quarry, with a spur running off to the shale quarry. Quarry floors were kept level but there was a rise of 22 feet from floor elevation up to the dumping point at the limestone primary crusher. This required 1100 feet of 2% grade, uncompensated for curvature, in the track between the quarries and the crusher.

At first one locomotive handled both the limestone and shale cars, the shale cars being at the head of the train, then the locomotive, and then the rock cars. Considerable time was lost in making up trains, in spotting cars for dumping and in switching cars in the quarries.

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After a year and a half, the heavier demand for stone and the increasing area of the quarry floors made it necessary to provide a second, 12-ton, gasoline locomotive to handle the shale cars independently. This made a much more flexible and economical operation and our stone was handled in that manner until early 1941.

During the early development of the quarries, a single spur to the face answered the need. As the length of the face increased, additional spurs to the face were added until by 1932 we had a complicated pattern of spur tracks spread out on the floor, bad in line surface and gauge, hard to keep cars or the locomotive on, and expensive to maintain and move.

So in 1932 we put in a circular track parallel to the face and as far out as the reach of the shovel dipper would permit. This was a distinct improvement, marred from time to time by occasional miscalculations of the powder man. His shots, intended to put rock just up to the track, usually were pretty good but every now and then either covered the track 10 feet deep or pushed it 40 or 50 feet out into the quarry. And it took a large crew of men to enlarge the circle after every traverse of the shovel along the face.

About this time the elder Mr. Farrell, then President of the Easton Company, began putting pressure on truck haul for quarries, supported by moving pictures and many figures. But when we asked him if we could equal or better our haulage costs with trucks he always, and regretfully, said no.

However, in the late 30's, the old equipment began to wear out and its limitations and that of the circle track became more bothersome; especially the fact that with the circle track we largely had to take the stone as it came, clean or dirty, and we have always had plenty of dirt. Further, our quarry crew had shrunk in numbers so that we had too few for the track work. Also, we wanted to develop another limestone opening with only a narrow entrance available.

So much for background; the succeeding discussion refers to the limestone quarry only except where shale is mentioned specifically.

In view of these conditions it appeared that while we could not justify a switch to truck haul on the basis of previous hauling costs, we could justify it on the basis of what future costs would be by the old system if we continued it.

Mr. Farrell had seen to it that we were fully informed on the utility and desirability of Easton semi-trailers and, after a brief survey and some inspection trips of other possibilities, we settled on Easton units.

We devoted considerable study to the matter of tractors. Most of our inquiries to people using trucks in quarries brought answers favoring heavy, expensive trucks for the service. But we found a few quarries in which Ford trucks were being used and performing well although with not very long service records. We finally decided to start with Fords, on the basis that if they stood up for a year we could exchange them for heavier trucks with little if any loss.

We have three semi-trailer units; one originally intended to haul shale but now used as a spare and a fill-in for limestone hauling. Shale is hauled in the rear dump dirt trucks. The trailers are Easton Model TR-10 with a rated capacity of $9\frac{1}{2}$ yards and they carry 14 tons of $2\frac{1}{4}$ yard shovel stone. The tractors are $1\frac{1}{2}$-ton Ford C.O.E. trucks, standard except that the frames are reinforced, equipped with Eaton axles and with units to actuate the air brakes on the trailer axles. The dirt trucks are duplicate units but without the special equipment and were selected thus so that they could be substituted for trailer service in an emergency. They carry 5-yard rear dump bodies.

The next consideration was roadway. We decided of course to use the old track grade for this and it was necessary to widen the cut through the ridge to secure passing room for the trucks and, incidentally, to get a one-way road working before removing the track. We ran the empty trucks temporarily over the ridge on the back haul to the quarry.

The necessity for a firm surface with good traction was of course obvious and we even considered concrete paving for the road, between the quarries and the crusher, and part way across the quarry floors.

Due to the cost and time element concrete would involve, it was decided to use a macadam type road. After preparing and grading the subgrade, a layer of one man stone was spread and placed roughly by hand. Then a layer of about 12 inches of gyratory crusher product, 5 inches and down, and finally a finish layer of hammer mill product, 1 inch and down. No compacting was attempted beyond truck movement over it in distributing the various layers. We secured a used, tractor-drawn road scraper and a used sprinkler wagon for maintaining the surface.

This roadway worked well and is still in satisfactory use. While it was new we used the scraper fairly often with some added fine rock and used the sprinkler to settle the dust and work it in as a binder for the first two summers. Since then we have used the scraper once or twice a month, and have discontinued the water tank entirely. Additional fine stone is used occasionally to fill in depressions in the quarry floor, rarely on the permanent roadway. The cost of roadway maintenance has been negligible.

Finally, and we think quite important, we hired an expert automobile mechanic who takes care of the lubrication, adjustment and repair, not only of the tractor trucks and trailers but also the dirt trucks, the bulldozer, the plant yard truck and the storeroom truck.

The units were put in service early in February, 1941 and are still in daily, effective use. They have hauled 1,830,000 tons of limestone with an aggregate travel of 130,000 miles, about 50,000 each for the two regular trucks. Maximum roadway grades 2½%.

Repairs have been quite moderate, principally confined to the truck frames which are light and which we reinforced heavily ourselves after the Ford Motor Company did its poor best. We are now considering substituting new Ford trucks of the same size, this time using standard engine mountings. The C.O.E.'s are no longer needed for close quarters; they are harder to work on and harder on drivers, particularly in hot weather.

The semi-trailers are still in excellent condition and will be continued in service. Aside from a little welding on the bodies and the replacement of false bottoms once, about six months ago, they have needed no repair.

Tire expense has been moderate but not low. Most of the failures have been due to cuts by sharp rocks on the quarry floor.

Cost figures are always interesting and the following are averages for our limestone quarry:

4 years, rail haul, spur tracks in quarry	5.36¢ per ton
8 years, rail haul, circle track in quarry	3.29¢ per ton
6 years, truck haul	4.30¢ per ton

To conclude, we have found the truck haul quite flexible, efficient and dependable in general, and the units selected better than we anticipated. Credit for the good results obtained goes to (a) expert maintenance, (b) careful drivers, (c) smooth roadways; probably in that order.

As for cost, it is our opinion that rail haul today would be at least 1½¢ higher per ton than for trucks.